



# NOAA Space Weather Plans



**Dr. Jennifer “Jinni” Meehan**

**National Space Weather Program Manager, National Weather Service, NOAA  
Executive Secretary, Space Weather Operations, Research, and Mitigation (SWORM)  
Interagency Working Group, National Science and Technology Council  
Designated Federal Officer, Space Weather Advisory Group**





# Overview

- History of NOAA support for NASA Human Spaceflight Program
- SWPC Mission
- Current Priorities -
  - Observations
  - Modelling
  - Testbed/R2O2R
- Admin Priorities - Space Framework and SWORM Priorities



# In the Beginning.....

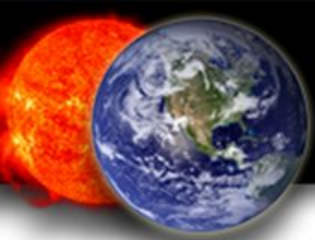
## Gemini – bridge to the moon

1965: The Environmental Science Services Administration (ESSA) is created in the Department of Commerce, incorporating the Weather Bureau and Space Disturbance Lab (SDL)

NASA reached out to ESSA SDL for space weather support for the Gemini and Apollo programs

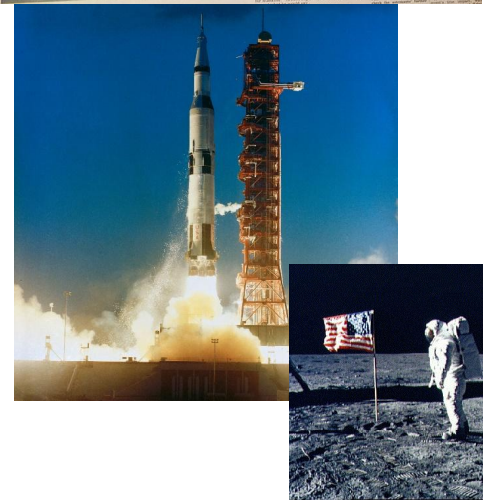
- SDL staff rotate to Houston for space weather interpretation and prediction
- The SDL Space Disturbance Forecast Center (SDFC) begins issuing daily Space Disturbance Forecasts in support of Gemini



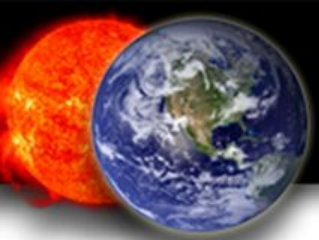


# Apollo Program

- ESSA Space Disturbance Lab continues warning and forecasting support from Boulder and with ESSA staff at Houston and at the SPAN Observatories
  - 1970 – The Environmental Science Service (ESSA) becomes National Oceanic and Atmospheric Administration (NOAA)
  - Space Disturbance Lab becomes Space Environment Lab
- No major space weather outbreaks during Apollo missions



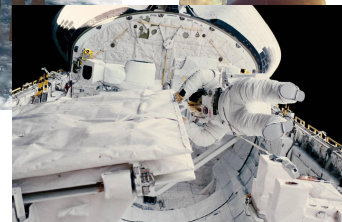
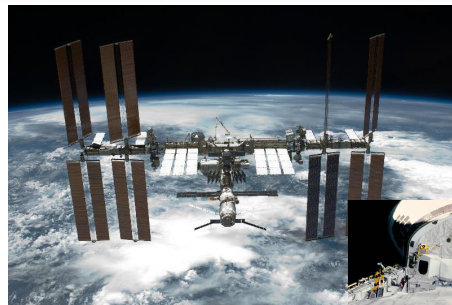




# Skylab, Shuttle and ISS Support

Space Environment Center (now SWPC) support:

- 24/7 support (continuous habitation)
- Daily briefings to SRAG
- L-3 day and L-10 day pre-launch shuttle briefings
- EVA-24 hrs and EVA-1 hr briefings
- Communications ramp up considerably during space weather outbreaks





# Current support for NASA SRAG

- NOAA Forecasters continue 24/7 support to NASA SRAG.
- SWPC accomplishes this via established, daily, scheduled calls with SRAG personnel about the latest solar activity conditions and space weather developments.
- Daily calls also serves as an opportunity to answer SRAG questions and provide additional ad hoc support requests; also allows SRAG to relay any upcoming EVAs or other mission support essential information and updates.
- SWPC also initiates episodic calls to SRAG personnel when space weather conditions warrant immediate updates and information.



# Space Weather Forecast Office

## 24/7 Operations

**Hazard Products:** Watch, Warning, Alert, Advisory

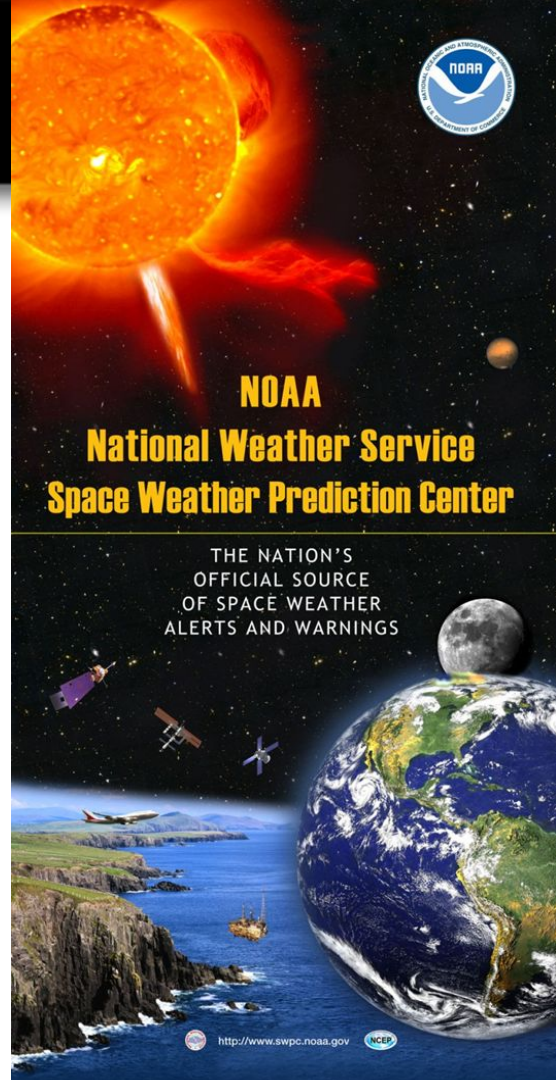
**Routine Products:** Analysis, Forecasts, Summaries

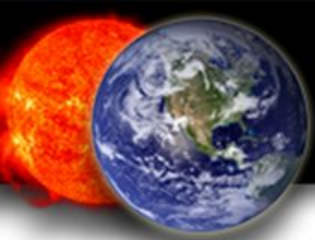
**Data Monitoring:** DSCOVR, GOES

**Impact-Based Decision Support Services:** NASA Space

Radiation Analysis Group; USAF 557th; FEMA; Electric Utilities;

Aviation Interests, and much more





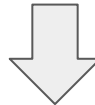
# NOAA Provides Operational Observations and Real-Time, Model-Based Prediction Services

**Observations:** Collecting and providing critical, real-time, continuous, operationally-dedicated space weather data and imagery for alert, watch, and warning services, and predictive modeling systems

**Modeling and R2O2R:** Introducing a modeling continuum that incorporates the contributions from industry, agency, and academic partners

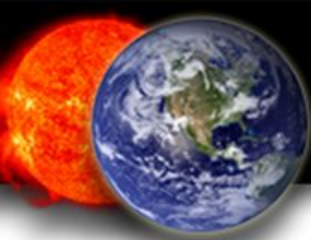
- The development of space weather numerical modeling is happening in the academic, research, and private sector communities

**Forecasts, Watches, and Warnings:** Providing regional and local specification and forecasts of space weather hazards, using indices and products suitable for objective decision-making



**Providing the Nation with space weather forecasts, warnings, and data critical to public safety, disaster preparedness, and the protection of the Nation's critical infrastructure**



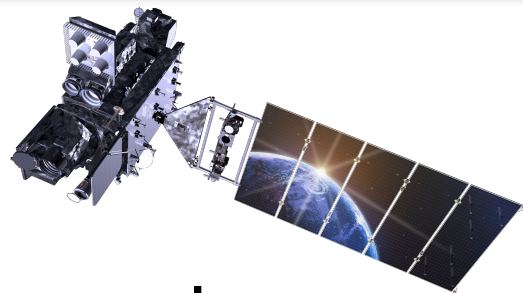


# Critical Observations to Support Operations and Validate Research

**GOES-16** operational as of Dec 2019

**GOES-17** operational as of Aug 2021

- instruments: EXIS, MAG, SEISS, SUVI

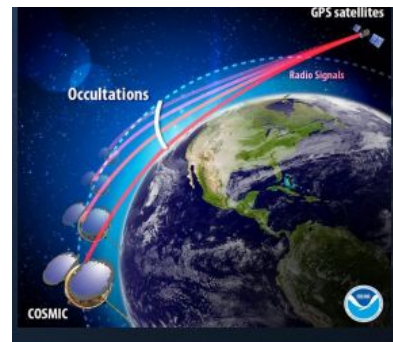


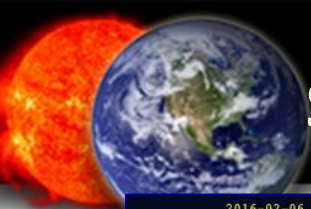
## Space Weather Follow-On + Operational NRL Coronagraph

- Rideshare to L1 with NASA's Interstellar Mapping and Acceleration Probe (IMAP) 2025
- FY22 appropriation bill includes \$173 million
- Host coronagraph on GOES-U, launch in 2024

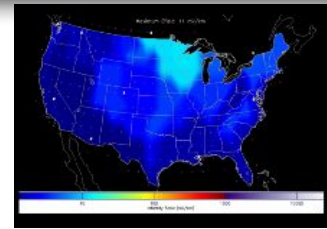
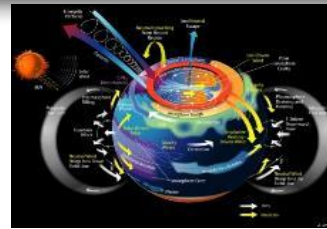
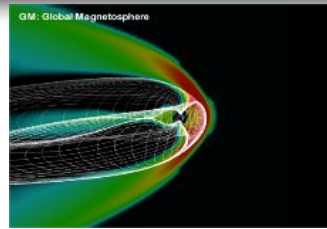
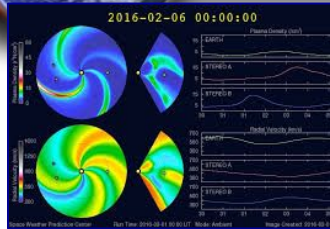
**COSMIC-2A** - six satellites in low-inclination orbits launched in June 2019

- Providing ~8,000 radio occultation (RO) measurements daily





# Sun-to-Earth Modeling Continuum for Space Weather



**GMU/AFRL**  
**WSA/Enlii**

**U. Michigan**  
**Geospace**

**NOAA/CIRES**  
**WAM-IPE**

**NOAA/USGS**  
**Geoelectric field**

**FAA**  
**CARI-7**

**Predict solar wind as it propagates from the Sun to Earth**

**Operational 2011**  
**Upgraded 2019**

**Predict and understand regional geomagnetic response to solar wind**

**Operational 2016**  
**Upgraded 2021**

**Predict and understand links between the upper and lower atmosphere during space weather events**

**Operational June 2021**

**Characterize and predict the regional electric field and associated currents that impact electric power grids**

**3D Operational Sept 2020**

**Characterize the radiation environment at airline altitudes**

**Operational 2019**

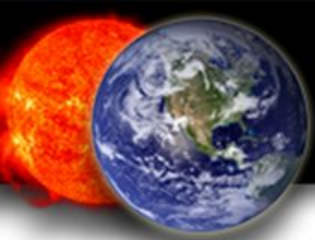
- A modeling framework that captures critical domains of the Sun-Earth system, beginning at the Sun and ending at Earth's surface
- Enabled by **SWORM** - a space weather watch/warning paradigm similar to terrestrial weather



# National Space Weather Strategy and PROSWIFT Act - Develop Formal Mechanisms for R2O2R

## Identify an effective R2O2R process for space weather:

- Partnerships with Government Agencies, Academia, Private Sector, International Partners
- Includes Community Coordinated Modeling Center (CCMC) at NASA GSFC in R2O
- Updating agreements with federal partners - Quad-Agency (**NOAA, NASA, NSF, DOD**) R2O2R MOU underway
- Applied-research opportunities through NASA ROSES Space Weather Science Applications Operations 2 Research program - targeting needs of aviation and space (radiation), satellite operators (drag and instrument impacts), and more
- Research-to-Operations (R2O)
  - Evaluate, Prototype, Transition within space weather testbed at SWPC
- Operations-to-Research (O2R) -
  - Continuous improvement of the existing operational models
  - Informs future capabilities and establishes research priorities

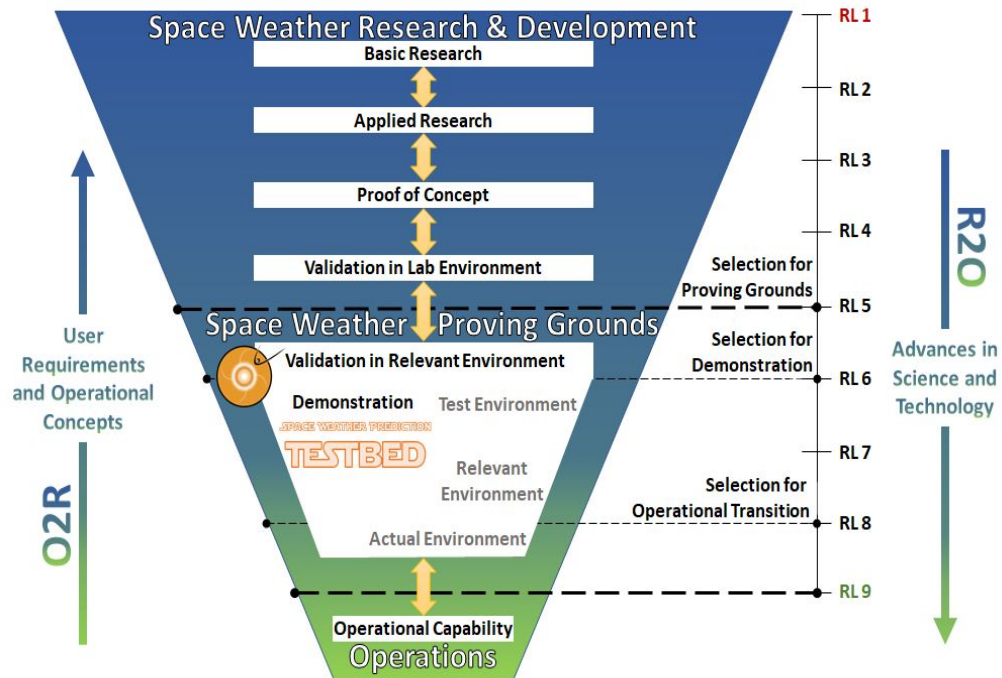


# Path to Operations

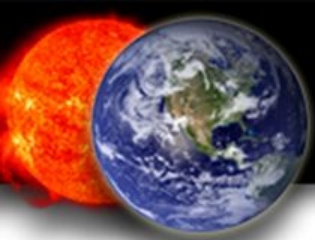
Sufficiently mature models will be selected for assessment in an operational environment via the Space Weather Testbed

Successful models will be transitioned into SWPC operations

Working with SRAG to explore new products and services to meet requirements








# Model Validation

Models must be validated to assess readiness for operations

SWPC is working with partners at the CCMC, NASA SRAG, and the research community, to validate SEP forecast models.

Coordinating community model validation campaigns through the COSPAR International Space Weather Action Teams (ISWAT) and SHINE SEP model validation working groups.



## ISWAT - International Space Weather Action Teams

Join forces to advance space weather understanding and capabilities to alert and shield society!

- HOME
- JOIN ISWAT ▾
- HOW WE WORK
- NEWS, EVENTS, ACTIVITIES ▾
- CONTACT US

**Team title:** SEP Validation

Team ID: H3-01

**Team Leads:**

- Katie Whitman (NASA JSC SRAG, Wyle, USA), [kathryn.whitman@nasa.gov](mailto:kathryn.whitman@nasa.gov)
- Phil Quinn (NASA JSC SRAG, Wyle, USA), [philip.r.quinn@nasa.gov](mailto:philip.r.quinn@nasa.gov)
- Hazel Bain (NOAA SWPC, CIRES, USA), [hazel.bain@noaa.gov](mailto:hazel.bain@noaa.gov)
- Ian Richardson (NASA GSFC, UMD, USA), [ian.g.richardson@nasa.gov](mailto:ian.g.richardson@nasa.gov)
- M. Leila Mays (NASA GSFC CCMC, USA), [m.leila.mays@nasa.gov](mailto:m.leila.mays@nasa.gov)

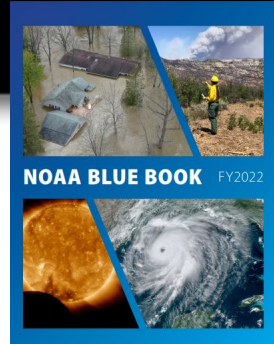
**Scoreboard Leads:**

- M. Leila Mays (NASA GSFC CCMC, USA), [m.leila.mays@nasa.gov](mailto:m.leila.mays@nasa.gov)
- Mark Dierckxsens (BIRA-IASB, Belgium), [Mark.Dierckxsens@aeronomie.be](mailto:Mark.Dierckxsens@aeronomie.be)



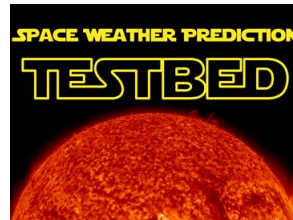
# R2O2R Framework and Testbed - Status

- FY 2022 President's Budget requests \$5 million for a space weather prediction capability ***“that will ensure national and global communities are ready for and responsive to space-weather events”***
- ***“The House FY22 CJS bill does include the full funding request for space weather by NOAA, including the Space Weather Prediction Testbed”*** - U.S. Representative Matt Cartwright (PA-08), Chairman of the Commerce, Justice and Science (CJS) Subcommittee of the House Appropriations Committee



## STATUS:

- Construction plans complete for buildout of a physical testbed space at SWPC in Boulder
- If funded, Space Weather Prediction Testbed (SWPT) facility construction will begin in 2022
- Select transition-candidate model for ACE evaluation
- SWPT “experiment”/tabletop exercise planned for 2022 for aviation community





# PROSWIFT-directed private and public partnerships - - forums for knowledge transfer and information exchange

**Space Weather Advisory Group (SWAG), managed by NOAA, shall advise the SWORM**

- 15 non-governmental representatives, 5 each from the academic, end-user, and commercial provider sectors
- Appointments began on Oct 1; first meeting - Dec 1, 2021



**Space Weather National Academies Space Weather Government-Academic-Commercial Roundtable**

- NASA, NOAA, and NSF will fund - nearing completion on funding effort (5 year)
- Assessing options now for who should serve on the Roundtable

***Both groups will facilitate advances in the space weather enterprise***



# Building Strength through Partnership

**New Era of Support - Artemis Lunar Missions and Lunar Surface Operations, Commercial Crew Flights, and future Mars Exploration Missions**

**Partnership with SRAG, the Community Coordinated Modeling Center (CCMC), and Moon 2 Mars (M2M) Office**

NONREIMBURSABLE INTERAGENCY AGREEMENT  
BETWEEN  
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
AND UNITED STATES DEPARTMENT OF COMMERCE  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)  
FOR SPACE RADIATION ENVIRONMENT SUPPORT TO NASA

ARTICLE 1. AUTHORITY AND PARTIES

The National Aeronautics and Space Administration, located at 300 E Street SW, Washington, DC 20546 (hereinafter referred to as "NASA") enters into this Interagency Agreement (hereinafter referred to as "IAA") in accordance with 51 U.S.C. § 20113(e). UNITED STATES DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, located at 325 Broadway, Boulder, CO 80305-3337 (hereinafter referred



## United States Space Priorities Framework (Dec 2021)

- The United States will maintain its leadership in space exploration and space science
- The United States will protect space-related critical infrastructure and strengthen the security of the U.S. space industrial base.

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